CHANGE MANAGEMENT

Clinical transformation requires changes in processes, technologies, and people. A successful CIS implementation must include plans for dealing constructively with overt and covert resistance to change arising from the anxiety of clinicians and supporting staff. Managing change requires that the people affected by change participate significantly in the process by which decisions are made and change is implemented.

The Greek philosopher Heraclitus believed that perpetual change is the natural law by which the universe operates. He never claimed change would be pleasant, or that we'd be eager to embrace it. In fact, change is inherently stressful, a precarious balance between harmony and discord, between what's comfortable and what's risky. Heraclitus" perspectives on change, formulated 2,500 years ago, uncannily presage the efforts of today's business enterprises to respond to the challenges of changing their business models and relationships. Health care providers are especially aware of the need to implement key changes in the way health care is delivered, to provide safer, more cost effective care to their patients. They have also learned, occasionally through painful experiences, that a purely technical solution — putting laptops in every hospital room, for example — does little to improve the quality and safety of patient care.

http://www.hctproject.com/documents.asp?d_ID=1853

Identified Benefits of EMR to Safety Net Organizations

- Enhanced clinical practice and patient care through the following:
  - Automate allergy, drug/drug and drug/food interaction alerts
  - Reduce prescription errors
  - Improve legibility
  - Enhance access to patient health information
  - Improve clinical documentation
  - Implement "best practice" clinical alerts
  - Automate access to patient education and after-care instructions
  - Automate use of standard treatment protocols and documentation templates
  - Define and evaluating clinical outcome measures
  - Enhanced chronic disease management and tracking
  - Contribute to the analysis of preventative health services
  - Evaluate clinical effectiveness of current health-related interventions
  - Enhance patient satisfaction
  - Assess health status of defined populations
  - Defining gaps in the provision of needed health services
  - Tracking utilization and efficacy of health screening
  - Improving clinician access to decision support tools
- Potential reductions in operating costs and enhanced revenue opportunities by:
  - Improve efficiency by eliminating time consuming chart searches & ensuring access to diagnostic testing results
  - Reduce expenses associated with medical errors, such as unnecessary care and malpractice costs
  - Eliminate redundant testing of patients
  - Reduce paper supply, space and expenses for paper records
  - Improve clinical documentation supporting higher levels of service coding - without increasing billing compliance risk

- Increase patient access and delivered services which increase clinic reimbursement opportunities

JAMIA Original Investigations

Research Paper ■

Development and Initial Validation of an Instrument to Measure Physicians' Use of, Knowledge about, and Attitudes Toward Computers

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Abstract This paper describes details of four scales of a questionnaire—"Computers in Medical Care"—measuring attributes of computer use, self-reported computer knowledge, computer feature demand, and computer optimism of academic physicians. The reliability (i.e., precision, or degree to which the scale's result is reproducible) and validity (i.e., accuracy, or degree to which the scale actually measures what it is supposed to measure) of each scale were examined by analysis of the responses of 771 full-time academic physicians across four departments at five academic medical centers in the United States. The objectives of this paper were to define the psychometric properties of the scales as the basis for a future demonstration study and, pending the results of further validity studies, to provide the questionnaire and scales to the medical informatics community as a tool for measuring the attitudes of health care providers.

Methodology: The dimensionality of each scale and degree of association of each item with the attribute of interest were determined by principal components factor analysis with orthogonal varimax rotation. Weakly associated items (factor loading < .40) were deleted. The reliability of each resultant scale was computed using Cronbach's *alpha* coefficient. Content validity was addressed during scale construction; construct validity was examined through factor analysis and by correlational analyses.

Results: Attributes of computer use, computer knowledge, and computer optimism were unidimensional, with the corresponding scales having reliabilities of .79, .91, and .86, respectively. The computer-feature demand attribute differentiated into two dimensions: the first reflecting demand for high-level functionality with reliability of .81 and the second demand for usability with reliability of .69. There were significant positive correlations between computer use, computer knowledge, and computer optimism scale scores and respondents' hands-on computer use, computer training, and self-reported computer sophistication. In addition, items posited on the computer knowledge scale to be more difficult generated significantly lower scores.

Conclusion: The four scales of the questionnaire appear to measure with adequate reliability five attributes of academic physicians' attitudes toward computers in medical care: computer use, self-reported computer knowledge, demand for computer functionality, demand for computer usability, and computer optimism. Results of initial validity studies are positive, but further validation of the scales is needed. The URL of a downloadable HTML copy of the questionnaire is provided.

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The potential benefits of the application of computers to medical care are well recognized[1]; however, physicians must adopt and utilize computer technology as a part of their practices if these benefits are to be realized. Some authors believe that the medical profession as a whole has been slow to utilize computers for patient care.[1,2]

Many factors affect the use of computers by physicians, including personality characteristics,[3,4] specialty,[5] prior computing experience,[5] and attitude toward computers and medical computing.[6–8] Young[7] notes "the nature of the doctor's work, his attitudes, interests, and enthusiasms" to be "the major reason for the non-acceptance of computer systems." Anderson et al.[5,9] found that physicians' attitudes were significantly related to hospital information system (HIS) use[9] and that these attitudes "account for a significant portion of variance in HIS use even when other variables are controlled. . . . "[5] For this reason, it is important to develop methods for understanding and accurately measuring attributes of physicians and other health professionals that may predict their acceptance and mode of use of computer systems and thus guide the design of such systems. These attributes include how physicians currently use computers and how much they know about computers as well as their relevant beliefs and attitudes. This need has already been recognized by Farrell et al.,[10] who note (in reference to practicing psychologists) that such measures "could be used to further explore the relationship between attitudes and computer implementation, to identify variables related to practitioners' attitudes toward computers, and to design and evaluate the impact of interventions aimed at overcoming practitioner resistance."

A common approach to such measurement is the self-administered questionnaire composed of multiple separate items organized into scales, with each scale assumed to measure a particular attribute or attitude dimension. Use of multiple items to assess each dimension is essential to the measurement process. To develop these questionnaires it is necessary to conduct studies that examine the reliability and validity of the measurement process itself. Such measurement studies are distinct from more common demonstration studies, which make descriptive or comparative assertions based on the results of measurements. Measurement studies are important because they: 1) determine the psychometric properties (reliability and validity) of an instrument and consequently the degree of confidence that can be placed in assertions based on that instrument, and 2) define and document the instrument for reuse by future researchers.[11]

Two important properties of an instrument determined by measurement studies are reliability and validity. Reliability is generally synonymous with precision and indicates the degree to which the measurement process is consistent or reproducible. Reliability may be quantified by administering an instrument to the same group of subjects multiple times (test–retest reliability) or by examining the concordance between multiple items provided once to a group of subjects (internal consistency reliability). Cronbach's *alpha*[12] is one commonly accepted measure of internal consistency reliability. The value of *alpha* ranges from zero (unreliable) to one (perfect reliability), with a value of .70 or greater considered acceptable for most purposes.[13] Validity is generally synonymous with accuracy and is the degree to which the process measures what it is intended to measure. Three kinds of validity are generally recognized: 1) content validity: do the items appear to measure what they are intended to measure? 2) construct validity: do the item scores intercorrelate with other measures as expected? and 3) criterion-related validity: do the item scores correlate with an external standard?[14]

Measurement studies have been conducted for instruments measuring attitudes toward computers among varying groups including students,[15–20] hospital information-system personnel,[21] psychologists,[10] and nurses.[22–24] These studies have provided well-defined instruments that have subsequently been used by other authors to examine the attitudes of new populations. For example, at least six studies[25–30] have examined nurses' attitudes toward computers using the "Nurses' Attitudes Toward Computerization Questionnaire" developed by Stronge and Brodt in 1985.[23] Several compendia of survey instruments that measure attitudes of workers both in and out of health care are available.[31–33]

A number of surveys of physicians' attitudes toward computers in medical care have been conducted over the past 30 years. Most[34–47] report only demonstration results and have not provided any evaluation of the psychometric properties of the measurement instrument employed. Others, as summarized in Table

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Table 1 ▪

Summary of Prior Psychometric Studies of Physicians' Attitudes Towards Computers, in Reverse Chronologic Order

Reference	No. of Subjects	A Priori Constructs (Questionnaire Sections)	A Posteriori Constructs (Factor Analysis Results)
Present study	771 academic physicians	1. Computer use 2. Knowledge of computing concepts 3. Demands on computer-based systems 4. Expectations of effects of computers on medicine and health care	1. Computer use 2. Computer knowledge 3A. Demand for high-level functionality 3B. Demand for ease of use 4. Expectations of computers
Brown and Coney (1994)[48]	51 interns	1. Computer anxiety 2. General perceived stress levels 3. Attitudes toward the application of computers in medicine	None
Dixon and Dixon (1994)[49]	18 academic physicians 58 residents	1. Attitudes toward clinical computer applications 2. Perceived ease of use of computers 3. Perceived usefulness of computers 4. End-user (computer) sophistication 5. Intention (of adopting computer technology) 6. Finesse	None
Shumway et al. (1990)[50]	7 academic physicians 24 private practice physicians 23 nurses 6 clinical pharmacists	1. Attitudes toward health care 2. Attitudes toward change 3. Attitudes concerning the professional role of health professionals 4. Attitudes concerning information-seeking behaviors 5. Attitudes toward hands-on use of computers	None
Anderson et al. (1985)[5] and 1986)[8,9]	650 private practice physicians[5,8] 148 medical students 141 residents 644 private practice physicians[9]	1. Perceived desirability of computer applications to medicine 2. Potential effects of computers on medical practice 3. Physician use of the HIS* 4. Physician prior computer experience 5. Physician involvement in professional associations	1A. Computer applications related to patient care 1B. Computer-assisted decision-making 1C. Computer applications that allow substitution for physician by computer or by allied health personnel 2A. Effects on the cost and quality of medicine 2B. Effects on physician autonomy and control 2C. Effects on physician's traditional role 2D. Effects on need for medical manpower 2E. Effects on the organization of health care 3. Physician use of the HIS 4A. Computer education 4B. Use of the computer 5. Four factors

*HIS, hospital information system.

Table 1 (Continued)

Reference	No. of Subjects	A Priori Constructs (Questionnaire Sections)	A Posteriori Constructs (Factor Analysis Results)
Zoltan-Ford and Chapanis (1982)[51]	121 physicians 125 certified public accountants 124 lawyers 151 pharmacists	1. Computer training 2. Computer availability 3. Computer usage 4. Experience with computers 5. General attitudes 6. General statements	A. Computer as a sound working machine B. Computer as dehumanizing, depersonalizing, impersonal, cold, and unforgiving C. Computer as a desirable and useful machine D. Computer as a slave to man E. Computer as fun, enjoyable, stimulating, and challenging F. Discontent with computer ease of use
Teach and Shortliffe (1981)[52]	64 academic physicians 66 private practice physicians 16 house staff	1. Expectations about the effect of computer-based consultation systems on medicine 2. Demands regarding the performance capabilities of consultation systems 3. Acceptability of different medical computing applications 4. Computing experience 5. Knowledge of computing concepts	1A. Effect of consultation programs on individual practitioners 1B. Effect of consultation programs on medical practice in general 2A. Performance demands 2B. System accuracy demands 1 & 2. Effect of computing systems on health manpower needs
Melhorn et al. (1979)[53]	44 medical faculty 49 medical students 36 nursing staff/students 51 other staff	1. Identical to Startsman and Robinson (1972)[54], plus: 2. Attitudes about computers at the host medical center	A. General evaluation of computers B. Willingness to use and a desire to learn more about computer-assisted diagnosis C. Potential threats of computers to employment D. Attitudes toward specific uses and scientific applications of the computer
Startsman and Robinson (1972)[54]	42 medical faculty 44 house officers 84 medical students 108 nurses and nursing students 60 other staff/students	None	A. General evaluation of computers B. Willingness to use or accept the use of computers C. Potential threat of computers to employment D. Possible benefit of the application of computers to the problems of hospitals
Reznikoff et al. (1967)[55]	"All full-time employees" of a psychiatric hospital, including professional and medical staff, nurses, and other staff	"Attitudes toward computers"	A. Factors I, VI, VIII: Usefulness and efficiency of computers in dealing with some of the burdensome aspects of living in an exceedingly complex society B. Factors III, IV, V, IX: Need for constant human control activity and the dangers of dehumanization in areas such as medicine C. Factors II, VII: Misapplication/Exploitation of computers and unwarranted assumptions about their future potential

1,[48–55] have provided psychometric information as part of their reported results. These studies have addressed a wide variety of constructs, which may be categorized as opinions on computer characteristics, computer effects on health care, computer effects on health care personnel, prior computer experience, general attitudes towards computers, attitudes toward computer use, attitudes toward computer use in medicine, and user characteristics. As shown in Table 1, each study typically begins with a set of a priori constructs: the attributes that the instrument is hypothesized to be assessing. The subsequent data analysis, often employing the statistical technique of factor analysis, generates a set of a posteriori constructs: what, based on the data, the instrument appears to be assessing.

Although it is possible to use instruments developed for other health professions to measure physicians' attitudes toward computers,[48] this approach may prove less than satisfactory. First, it is not known whether physicians and other professionals share a similar structure of attitudes and beliefs. Attitudes toward computers have been shown to differ among professions, including professions within health care.[50,51] Such differences are not surprising, given the differing training, experience, roles, and activities of these professions. Even more important, instruments developed for other professions (e.g., nursing) may not address the unique training, roles, activities, and responsibilities of physicians.

While the literature on attitudes of physicians toward computers is fairly extensive, some important attributes have not been rigorously explored. These include for what purposes health professionals actually use computers and how much they know about the underlying technology. While several authors have previously measured physician attitudes toward the use of computers or have measured actual physician use of computers in medicine, only Anderson et al.[5,8,9] have addressed computer use as a psychologic construct. To our knowledge, psychometric analysis of physician knowledge of computers has not been previously reported. One prior study[49] measured end-user computer sophistication without specification of parameters describing how accurate or precise measurements using these methods would be. Teach and Shortliffe's widely cited study, published in 1981,[52] employed as a priori constructs physicians' expectations, demands, acceptability, experience, and knowledge of computer-based consultation systems. While the wide recognition of this study suggests that the included constructs are of importance to the field, the focus on consultation systems and the use of a convenience sample of professional meeting attendees to validate the instrument are factors limiting the ability to generalize their results.

Study Goals and Questions

Because physicians' attitudes and other attributes appear to be important in determining the use of computers and because existing instruments may be less than satisfactory for measuring these attributes, we sought to develop an instrument specifically designed for physicians that measures with well-defined psychometric properties four important attributes regarding computers in medical care. To these ends, we convened a working group to modify the instrument originally used in the often-cited Teach and Shortliffe study.[52] After developing the questionnaire,* we administered it to academic physicians at five institutions, generating a study sample with 771 subjects. The resulting data allowed us to explore the psychometric properties of the item sets (scales) purported to address each attribute:

- Is the dimensionality of each attribute, as measured by the scale, as hypothesized?
- Which items appear not to address the attribute and thus not to belong in the item set?
- What is the reliability of the scales formed by these item sets?
- To what extent does each scale appear to be a valid measure of the associated attribute?

Demonstration aspects of this research, focusing on the measured values of the attributes and their relationships to a variety of physician characteristics, have been the subject of some preliminary work[56,57] and will be the subject of a future report.

Methods

Instrument

In developing a questionnaire rooted in the instrument developed by Teach and Shortliffe,[52] our goal was to develop an instrument both more general than the original in its evaluation of physicians' attitudes toward computer-based clinical decision aids and more representative of the current medical computing environment, yet similar enough to allow comparison with the results of the original study. In addition, we designed the new instrument to include measures of computer use, not included in most prior studies, and

*Available online at ⟨http://www.med.virginia.edu/~wmd4n/medsurvey.htm1⟩

to specifically address the roles and activities of physicians.

To develop the instrument, we established a six-member group experienced in medical informatics and evaluation/measurement techniques. The group comprised two of this manuscript's coauthors (WMD and CPF) as well as four persons whose contributions are cited in the acknowledgments. The group engaged in an item-design process that proceeded over four months. After reviewing the original Teach and Shortliffe instrument and results of the reported study of its measurement properties,[52] the group conceptualized four physician attributes to be assessed by the revised instrument: 1) extent of computer use; 2) self-reported knowledge of computer technology; 3) feature demand: how sophisticated information systems must be before physicians would be willing to use them; and 4) optimism about the impact of information technology on health care. As indicated in Table 1, these attributes closely resemble those addressed by the Teach and Shortliffe instrument. The new instrument was created by adding and deleting items from the original. Other items were modified to broaden their scope or update them in light of more recent technology. The final instrument, which has been briefly described elsewhere,[56,57] consists of 89 items in four sections:

- Section 1: *Demographics.* Respondent's age, gender, medical specialty/subspecialty, and percentage of professional time spent in each of the typical activities of an academic physician (clinical care and clinical teaching, didactic teaching, research, administration).
- Section 2: *Computer Experience.* Number of hours of hands-on computer use per week, type of computer(s) used (IBM-compatible, Macintosh, terminal), configuration and location of computer(s) used (desktop at office, desktop at home, laptop), extent of prior computer training and experience, and self-rated computer sophistication. This section also included a set of ten items hypothesized to assess the "computer use" attribute. Each item listed a specific task undertaken by an academic physician along with five options for the respondent to indicate the relative frequency with which he or she *personally* uses a computer for this task.
- Section 3: *Computer Knowledge.* This section comprised the 18 items used to assess the "self-reported computer knowledge" attribute. For each item, using a three-point response scale, respondents indicated the extent of their understanding of the distinction between a pair of medical computing concepts—for example, "hardware versus software." This format was adapted directly from the Teach and Shortliffe instrument.
- Section 4: *Applications of Computers in Medicine.* This part of the survey included three subsections. The first listed 18 potential functions of computers in medicine and asked the respondent to indicate the six considered highest priority and the six considered lowest priority for future system development. This subsection is not viewed as measuring an attribute of the respondent and is not further considered here. The second subsection included 17 items assessing the attitude of "feature demand." Each item presented a feature or capability of a medical computing system. Using a five-point scale, respondents indicated the extent to which it was necessary that a system have each feature. The third subsection included the 18 items assessing the "computer optimism" attribute, which was modified from the "expectations" scale in the Teach and Shortliffe instrument. Each item listed a potential effect of computers on medicine or health care. Using a five-point reponse scale, the respondent indicated the extent to which each effect is considered beneficial or detrimental.

Sample

The sample consisted of 1,478 full-time physician faculty members in the Departments of Internal Medicine, Surgery, Radiology, and Radiation Oncology at Stanford University, the University of North Carolina at Chapel Hill, the University of California at San Francisco, Northwestern University, and the University of Illinois at Chicago. Responses were received from 771 subjects, for a response rate of 52%. The four specialties sampled reflect a diversity of medical practice. The institutions in the sample span a range of governance modes and geographic regions.

Administration Procedure

Questionnaires were distributed via campus mail accompanied by a cover letter generated by a faculty member identified with medical informatics at each institution. The cover letter assured confidentiality of the responses. Completed instruments were returned via campus mail. A second questionnaire was mailed to all subjects four to five weeks after the initial mailing, with a response requested only from those who had previously not responded. It is estimated that the instrument required 20 minutes to complete.

Analysis

Responses were entered into a personal computer spreadsheet and checked for accuracy. Analyses were

Table 2 ■

Factor Analysis of Computer Use Item Set

Aspect of Computer Use	Mean	SD	Factor Loading
Presentation preparation	4.19	1.18	.82
Academic writing	4.38	1.07	.77
Literature searching	4.25	1.12	.76
Statistical analysis	3.69	1.54	.69
Clinical/didactic teaching	2.64	0.98	.60
Communicating with colleagues	2.77	1.05	.53
Obtaining diagnostic or therapeutic advice	2.16	0.92	.48

NOTE: Response options ranged from 1 ("never perform this task") to 5 ("always use computer for this task").

performed using Microsoft Excel for Windows version 5.0 and the statistical analysis program SYSTAT for Windows version 5.05 (SYSTAT Inc., Evanston, IL).

Analyses focused on the four item sets hypothesized to address computer use, computer knowledge, feature demand, and optimism. Using pairwise deletion of missing values, we conducted a principal components factor analysis with orthogonal varimax rotation for each item set.[58] Each analysis was performed initially specifying one, two, and three-factor solutions. The sorted factor loadings, eigen values,[58,59] and scree plots[60] resulting from these analyses were examined to identify the number of dimensions or factors that made up the best solution for each item set. Some respondents had multiple missing values within an item set. We therefore established, for each item set, a threshold number of responses necessary to include the subject in the factor analysis of that set. Subjects below the threshold were excluded.

After determining the dimensionality of each item set from the factor analyses, we examined the factor loadings to determine whether all items in the set were associated with the attribute of interest. Items with a factor loading less than .40 were deleted. We computed the reliability, using Cronbach's *alpha* coefficient, of the resulting item set for each attribute. The reliability coefficient indicates the precision of measurement conducted by assigning each respondent an attribute score based on the summed (or averaged) responses across the items in the set.

The methods used in this study also allowed us to address some aspects of the validity of each attribute. Content validity was addressed through the instrument development process, both by basing the items on the prior Teach and Shortliffe instrument[52] and by collegial development of the new items using a panel experienced in medical informatics. Construct validity was established in part by the results of the factor analysis. We hypothesized that the use, knowledge, and optimism attributes would be unidimensional. Based on the Teach and Shortliffe study,[52] we expected a multidimensional structure for the feature demand scale. Construct validity was also explored by examination of the correlations among the attributes themselves and by examination of correlations between the attributes and other characteristics of the respondents as measured by selected other items of the survey. Specifically, we hypothesized that the computer use and computer knowledge attributes should be highly intercorrelated, whereas the other attributes should be only modestly intercorrelated. In the special case of the item set addressing computer knowledge, subsets of the items were hypothesized to fall into three categories of difficulty. Higher mean scores for items seen as less difficult would be evidence of the construct validity of this scale. Criterion-related validity was not addressed explicitly in this study.

Results

In this section we first report some demographic characteristics and other characteristics of the respondents. We then report factor analysis results, with reliability indices, for each item set. Following this, we include a section addressing validity of all attributes.

Respondents

Of the respondents (n = 771), 80.4% were male; the average age was 45.0 (± .4)† years. The distribution of specialties was 55.6% internal medicine, 23.9% surgery, 11.5% radiology, and 2.6% radiation oncology. An additional 6.4% of respondents reported specialties in other fields, primarily emergency medicine. Since these persons were on mailing lists of the targeted departments and likely had joint appointments, we retained them in the sample.

Respondents indicated that they devoted, on average, 49.1% (± .9%) of their professional time to clinical care and clinical teaching, 26.7% (± .9%) to research, 15.3% (± .6%) to administration, and 8.9% (± .3%) to didactic teaching. They reported a mean of 9.5 (± .3) hours of hands-on use of a computer per week. The modal respondent had participated in one (of six possible) types of computer training, with "self-guided learning about computers" as the dominant type. Respondents self-rated their computer sophistication on a five-point scale ranging from "very unsophisticated" (coded to one) to "very sophisticated" (coded to five). Mean score was 2.8, with a mode and median of 3.

†Standard error of the mean.

Factor Analyses and Reliabilities

Items Assessing Computer Use

For the set of ten items addressing computer use, response options ranged from "Never perform this task" (coded to one) to "Always use a computer" (coded to five). Excluded from analysis were the responses of 87 physicians who responded "zero" to a preceding question, "In a typical week, how many hours do you personally use a computer hands-on?" Therefore, the results for this item set reflect only computer users in the sample. Also excluded were the responses of three additional physicians who completed less than eight of the ten items. Results of the remaining 681 respondents, including only those items with factor loading greater than .4 and sorted by factor loading, are provided in Table 2. Scree-plot analysis supported a one-factor solution including seven of the ten items and explaining 46% of the total variance. The reliability of the resulting seven-item scale was .79.

Adopting a one-factor solution necessitated that three items relating primarily to clinical uses of computers ("documenting patient information," "accessing clinical data," and "scheduling patient appointments") were eliminated from the scale due to low factor loadings. This affected the interpretation of the scale in ways that will be discussed below.

Table 3 ■

Factor Analysis of Computer Knowledge Item Set

Concepts to be Distinguished	Difficulty*	Mean	SD	Factor Loading
Client–Server	D	1.88	0.81	.77
Field–Record	I	1.93	0.85	.75
Electronic mail–Electronic bulletin board	I	2.72	0.52	.72
Free text–Coded data	E	1.88	0.80	.72
Database–Knowledge base	I	2.01	0.76	.71
Data in memory–Data on disk	E	2.55	0.62	.70
Digital–Analog	E	2.29	0.80	.69
Relational database–Flat-file database	D	1.60	0.79	.69
Full-text database–Bibliographic database	I	2.09	0.83	.68
Interpreter–Compiler	D	1.52	0.74	.68
Mainframe computer–Personal computer	E	2.72	0.52	.64
Entities–Relationships	D	1.44	0.69	.60
Images–Graphics	I	2.22	0.69	.57
Floppy disk–Hard disk	E	2.84	0.41	.55
Hardware–Software	E	2.86	0.37	.55
ICD9-CM–SNOMED	D	1.33	0.58	.47
Forward chaining–Backward chaining	D	1.16	0.43	.44
Sensitivity–Positive predictive value	I	2.37	0.76	.43

NOTE: Responses ranged from one ("I don't understand the distinction at all") to three ("I can define the distinction precisely").
*D, difficult; I, intermediate; E, easy.

Table 4 ■

Factor Analysis of Feature Demand Item Set

System Features	Mean	SD	Factor A Loading*	Factor B Loading*
Explain rationale for patient care advice	2.00	0.86	.78	.03
Provide accurate treatment recommendations	2.20	0.97	.74	.14
Make accurate diagnoses	2.07	0.99	.73	.12
Quantify the uncertainty of recommendations	2.16	0.88	.71	.00
Provide multiple alternative patient care recommendations	2.32	0.89	.65	.05
Allow browsing of information as well as providing specific advice	2.07	0.78	.62	.02
Take patient preferences into account when giving advice	2.76	0.95	.58	.01
Display images in less than 30 seconds	2.43	0.90	.11	.65
Respond to queries in less than 5 seconds	2.25	0.90	.06	.64
Allow access at any place in clinical setting	1.74	0.76	.08	.60
Allow implementation without any change in existing clinical routines	3.19	0.87	.02	.57
Function without any "down time"	1.81	0.82	.13	.55
Allow interaction without use of keyboard	3.41	0.86	.00	.53
Be learnable in less than 2 hours	2.30	0.93	.01	.52
Allow data entry in user's own words without requiring special codes	2.16	0.88	−.02	.41

NOTE: Responses ranged from 1 ("vitally necessary") to 4 ("not necessary").
*Factor A represents "demand for sophisticated features," while Factor B represents "demand for use ability."

Items Assessing Computer Knowledge

For this set, responses to each pair of computing concepts ranged from "I don't understand the distinction at all" (coded to one) to "I can define the distinction precisely" (coded to three). Responses of 16 physicians who completed fewer than 16 of the 18 items were excluded. Results for the remaining 755 respondents are provided in Table 3, sorted by factor loading. The scree plot supported a one-factor solution explaining 41% of the total variance. All 18 items

Table 5 ■

Factor Analysis of Optimism Item Set

Effect of Computers on Health Care	Mean	SD	Factor Loading
Enjoyment of medicine	3.58	0.76	.72
Clinician–patient rapport	2.9	0.69	.68
Status of medicine	3.26	0.71	.67
Quality of health care	3.92	0.61	.66
Clinician self-image	3.18	0.63	.66
Humaneness of medicine	2.82	0.69	.65
Patients' satisfaction	3.34	0.67	.64
Health care team interactions	3.71	0.80	.60
Clinician autonomy	3.18	0.80	.60
Costs of health care	3.87	0.74	.54
Generalists' management	3.69	0.69	.52
Privacy	2.74	0.78	.51
Continuing medical education	4.18	0.58	.49
Access to knowledge	4.47	0.57	.44
Medical/ethical dilemmas	3.14	0.63	.43
Role of government	2.87	0.94	.42

NOTE: Responses ranged from 1 ("highly detrimental") to 5 ("highly beneficial").

displayed factor loadings greater than .40 and were retained. The reliability of the resulting scale was .91.

Items Assessing Feature Demand

For this item set, respondents rated each of 17 features of computer systems on a response scale ranging from "Vitally necessary" (coded to one) to "Not necessary" (coded to four). Responses of 86 physicians who completed less than 15 of the 17 items were excluded, leaving 685 respondents in the analysis. As shown in Table 4, factor analysis suggested that this item set was two-dimensional.

Two items ("Availability of on-line help" and "Confidentiality and security better than the paper record") displayed factor loadings of less than .40 for both factors and were eliminated from both scales.

The first factor explained 23% of the total variance and included seven items with a reliability of .81. By inspection of the items loading on this first dimension, it was characterized as "demand for sophisticated computer features" as measured by demand for the capability to explain the rationale for patient care advice, provide accurate treatment recommendations, make accurate diagnoses, and other functions as shown in Table 4.

The second factor explains 17% of the total variance and included eight items with a reliability of .69. It was characterized as "demand for usability" as measured by demand for the capability to respond to queries in less than five seconds, display images in less than 30 seconds, allow access at any place in clinical setting, and other functions as shown in Table 4.

Items Assessing Optimism

In this set of 17 items, responses ranged from a belief that each stated impact of computers on health care would be "highly detrimental" (coded one) to "highly beneficial" (coded five). Responses of 50 physicians who completed less than 16 of the 17 items were excluded. Results of the remaining 721 respondents are provided in Table 5, sorted by factor loading. Results were consistent with a one-factor solution.

One item ("access to health care in remote or rural areas") displayed a factor loading of .39 and was eliminated from the scale. The resulting one-factor, 16-item scale explained 34% of the total variance with reliability of .86.

Attribute Score Construction and Validity Analyses

As indicated previously, content validity for the item sets was addressed by grounding the questionnaire development in an earlier survey instrument and in the development of the form with guidance from an expert panel. Construct validity was established in part by the factor analyses and in part through an additional set of correlational analyses described separately for each item set below. To conduct these analyses, we first computed for each respondent a score for each attribute by summing over the items retained for each attribute. Because the feature demand item set was two-dimensional, five attribute scores were generated for each respondent. Because of the multiple comparisons made, only p values less than .01 were considered significant.

Tables 6 and 7 report correlation coefficients among the attribute scores and between the attribute scores and specific other items in the questionnaire that were employed in the construct validation studies.

For the computer-use items, we hypothesized that respondents with higher scores on the computer-use attribute would report greater times of hands-on com-

Table 6 ■

Correlations Between Attribute Scores and Other Variables

	Hands-on Computer Time	Computer Training	Self-reported Computer Sophistication
Computer use	+.45*	+.21*	+.50*
Knowledge	+.43*	+.36*	+.66*
Demand: Functions	−.04	−.08	−.00
Demand: Usability	+.04	+.06	−.00
Optimism	+.14*	+.19*	+.24*

*$p < .01$.

puter use, more computer training experience, and greater self-reported computer sophistication. As shown in Table 6, all three posited correlations were positive and significant.

For the computer knowledge items (see Table 3), each of the 18 items had been placed a priori into categories seen as "easy," "intermediate," or "difficult." As a test of construct validity it was expected that the mean responses to items in each of these categories would differ. The means (± SEM) were: 2.48 (± .02) for the "easy" items, 2.2 (± .02) for the "intermediate" items, and 1.5 (± .02) for the "difficult" items. By repeated measures analysis of variance, this difference was highly significant ($F_{2,1498}$ = 2903.8, p < .0001). It was also hypothesized that respondents with greater computer knowledge would display greater levels of self-reported computer use, computer training, and computer sophistication. As shown in Table 6, these correlations are both positive and significant.

For the feature demand items, it was expected that *less* demanding respondents would spend more time with computers. Results of the correlational analysis, provided in Table 6, revealed a small and nonsignificant correlation.

For the optimism items, we hypothesized that respondents more optimistic about the impact of computers on health care would display greater weekly computer use, computer training, and computer sophistication. As shown in Table 6, small but still significant positive correlations are present.

Correlations among the five attribute scores are reported in Table 7. As hypothesized, a sizable and significant positive correlation is present between computer use and computer knowledge. Other correlations are small, even though some are significant because of the large sample size.

Table 7 ■

Correlations Among Attribute Scores

	Computer Use	Knowledge	Demand: Functions	Demand: Usability	Optimism
Computer use	1	+.45*	−.00	−.06	+.18*
Knowledge		1	−.01	+.01	+.20*
Demand: Functions			1	+.16*	−.05
Demand: Usability				1	+.03
Optimism					1

*p < .01.

Discussion

This report has focused on the measurement properties of a survey instrument to assess aspects of physicians' use, knowledge, and beliefs about computers in health care. This work differs in several ways from most prior studies of physicians' attitudes towards computers in medical care. First, the sample size of 771 is larger than that of prior works. Second, our work was guided by the earlier study of Teach and Shortliffe[52] with defined a priori attributes and item sets hypothesized to assess each attribute. Third, the study distinguishes measurement issues, reported here, from demonstration issues to be reported in a separate report later.

Computer Use Attribute

Of the four attributes evaluated, the factor structure of the items addressing computer use was the least clear. The one-factor solution covered seven aspects of computer use; however, only one item directly relating to clinical computing (obtaining diagnostic/therapeutic advice) was retained. The remaining clinical items (documenting patient information, accessing clinical data, scheduling patient appointments) exhibited low loadings on the single factor and were excluded. A two-factor solution (not included) for this attribute created two four-item factors readily interpretable as "academic computing" and "clinical computing"; however, the two remaining items loaded on both factors. Also, while the four items loading on the "academic" factor in a two-factor solution would have resulted in a scale with acceptable reliability, the four items loading on the "clinical" factor exhibited a reliability level too low to be useful for research. Therefore, we rejected a two-factor solution.

To the extent that these academic physicians have a single measured value of "computer use," this use supports academic rather than clinical responsibilities; there is only weak evidence here to support "clinical computer use" as a construct. This may be attributable to the fact that end-user tools supporting academic activity have been widely available for two decades, whereas the analogous end-user tools for clinical computing are relatively new at the institutions included in this study. Item sets assessing computer use should be revalidated in the near future to see whether the development and use of clinical computing applications will change this result.

Computer Knowledge Attribute

This scale measures one factor with high reliability and with all items retained. The Teach and Shortliffe study measured knowledge of computing concepts in a similar way with 22 items but did not conduct factor analysis of responses. Although our scale is based on theirs, we extended their work by generating subsets of items purported to be of differing levels of difficulty. The finding that items hypothesized to be more difficult generated lower mean scores adds substantially to the evidence supporting construct validity of this scale.

It is important to emphasize that this item set measures perceived knowledge, rather than actual knowledge as might be determined by a test administered under controlled conditions. We felt, as apparently did Teach and Shortliffe, that measuring perceived knowledge was a more practical strategy both because testing of actual knowledge may have been resented by respondents and because such testing could not have been administered under controlled or proctored conditions.

Feature Demand Attribute

This study confirmed the findings of Teach and Shortliffe that physicians' demand for functionality of computer systems is multidimensional. Examining the "demand" construct, they discovered two factors—demand for performance and demand for system accuracy. Our data differentiated two subscales that relate closely to those factors: the "sophisticated features" subscale taps a physician's belief that systems must provide high level functionality, and the "usability" subscale taps a belief that systems must be user-friendly, ergonomic, and convenient. The differentiation of these subscales seems intuitive, as physicians who feel strongly about one dimension could feel very differently about the other. Support for validity of these subscales derives primarily from the development process and the factor analysis. An anticipated negative correlation between hours of hands-on computer use and feature demand was not found in the data.

Optimism Attribute

Several studies have undertaken factor analyses of the attitudes of physicians towards the effect and application of computers to medical care. Similar to our one-factor solution, Startsman and Robinson[54] described a factor of "possible benefit of the application of computers to the problems of hospitals," and Melhorn et al.[53], using an almost identical instrument, uncovered a single factor of "attitudes toward specific uses and scientific applications of the computer." The Teach and Shortliffe[52] paper, referring to computer-based consultation systems, described as separate factors the effects of computers on individual practitioners, medical practice in general, and health manpower needs. Anderson et al.[5,8,9] discovered five factors, as listed in Table 1. Our data, based on a large sample, offer strong support for a more parsimonious one-factor solution and the consequent greater reliability it provides for attribute measurement. The correlations between optimism scores and computer use, training, and sophistication, although statistically significant, are smaller than expected. This may be because the clinical orientation of the item set differs from the primarily academic computer use of the respondents.

This study has three important limitations that merit discussion and further research. These relate to the survey sample itself, the response rate to the survey, and the preliminary nature of the validity studies.

The survey sample consisted of academic physicians in four departments that were selected to represent the range of medical practice. Sampling entire departments was a deliberate strategy to maximize return rate, because a small number of departmental chairs could then be asked to promote the survey. The five participating institutions included those where the investigators were themselves located or had close colleagues who agreed to administer the survey. Methodologically, the five institutions comprised a convenience sample. The sample is therefore not completely representative of all academic physicians, and academic physicians are not, themselves, representative of all physicians or other care providers. Differences in discipline, type of responsibility, and practice volume will affect attitudes. For these reasons, the results of the study could not be generalized, even if all physicians in the sample had returned the survey. Researchers who wish to apply this instrument to other populations will need to establish reliability and validity for those populations.

The response rate of 52% raises the additional question of whether the responding group is representative of the sample surveyed. Bias in survey research caused by nonresponse has been extensively studied. As illustrated in examples provided by Kish,[61] such biases typically disappear as response rates approach 80%. So while the researcher can generally be confident with an 80% response, a survey with a lower response rate is at risk. Two strategies are possible to minimize this risk. One is the use of extensive, but expensive, methods advocated by Dillman[62] to maximize survey returns; the second is an a posteriori approach of studying a relatively small number of nonrespondents to see whether they differ from respondents on specific characteristics. Although limitations imposed by sampling and nonresponse are of less concern in this study, which explores the measurement properties of an instrument, than they would be in a study whose purpose was to estimate the mean values of various parameters in a sample, future studies designed to provide a more complete validation should use one of these methods.

Finally, the validity studies conducted and reported in this paper are themselves preliminary in nature. Based on these findings, other investigators can employ this instrument with substantial confidence about the reliability of the scales but with less confidence that the scales measure what the investigators claim. Further validity studies are necessary to complement the initial content validity and construct validity investigations reported here. For example, criterion-related validity studies might administer to a sample of subjects our instrument along with a proctored test of computer knowledge in which the respondents must answer questions. This study would explore how well the self-reported computer knowledge, measured by our instrument, estimates "gold standard" computer knowledge as measured by an actual test. Another type of validity study, a construct validity study, would compare the responses of groups of physicians who, on theoretic grounds, would be expected to differ markedly in their responses. This would be done, for example, by administering the survey to graduates of medical informatics training programs and comparing their responses to those in a general sample.

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Computers in Medical Care Survey

I. Demographics

a. Your age: ________

b. Your gender: ❑ Female ❑ Male

c. In which area of medicine do you currently specialize (check only one)?

❑ Cardiology
❑ Cardiothoracic surgery
❑ Critical care
❑ Emergency medicine
❑ Endocrinology
❑ Gastroenterology
❑ General internal medicine
❑ Infectious disease
❑ Nephrology
❑ Neurology
❑ Neurosurgery
❑ OB/GYN
❑ Oncology
❑ Ophthalmology
❑ Orthopedics
❑ Otolaryngology
❑ Pulmonary medicine
❑ Radiology
❑ Radiation oncology
❑ Rheumatology
❑ Surgery, general
❑ Urology
❑ Vascular surgery
❑ Other________________
____

d. Over the course of an academic year, what percent time do you spend in the following activities?

Clinical care and clinical teaching	%
Didactic teaching	%
Research	%
Administration	%
Other (Specify: ________________ ________________________________)	%
TOTAL	**100%**

II. Computer Experience

a. In a typical week, how many hours do you personally use a computer hands-on? __________ hours

If you answered zero, go to question e.

b. What kind(s) of computer(s) do you use? (Check all that apply)

❑ Macintosh
❑ IBM PC or compatible
❑ Terminal connected to a remote mainframe computer (e.g., hospital information system)
❑ High-performance scientific workstation
❑ Other (explain) ____

c. To what extent do you personally use a computer for each of the following professional tasks? Please circle your answer.

1. ***Never perform this task***
2. ***Perform*** this task but ***never*** use a computer
3. ***Sometimes*** use a computer
4. ***Often*** use a computer
5. ***Always*** use a computer

Documenting patient information (e.g., history & physicals, progress notes)	1	2	3	4	5
Accessing clinical data (e.g., laboratory data, EKGs, radiology reports)	1	2	3	4	5
Communicating with colleagues	1	2	3	4	5
Obtaining advice on a specific patient's diagnosis or therapy	1	2	3	4	5
Scheduling patient appointments	1	2	3	4	5
Writing (e.g., grants, research papers, teaching material)	1	2	3	4	5
Preparing presentation slides or overheads	1	2	3	4	5
Performing statistical analysis on clinical or research data	1	2	3	4	5
Searching the medical literature (e.g., MEDLINE)	1	2	3	4	5
Teaching students and residents	1	2	3	4	5

d. What kind(s) of computer(s) do you routinely use? (Check all that apply)

- ❑ Desktop computer at your office
- ❑ Desktop computer at home
- ❑ Portable or notebook computer
- ❑ Other (please specify:____)

e. What training or experience with computers have you had? (check all that apply)

- ❑ Formal course(s) in computer science or related field
- ❑ Formal medical school training in computers
- ❑ Formal residency or fellowship training in computers
- ❑ Formal workshops or conferences on computers for which I received CME credit
- ❑ Workshops or conferences on computers for which I did ***not*** receive CME credit
- ❑ Self-guided learning about computers
- ❑ None

f. On the whole, how sophisticated a computer user do you consider yourself?

- ❑ Very sophisticated
- ❑ Sophisticated
- ❑ Neither sophisticated nor unsophisticated
- ❑ Unsophisticated
- ❑ Very unsophisticated

III. Computer Knowledge

Below are a set of paired terms that relate to computers in medicine. Please score your knowledge of the **distinction** between the terms in each pair, using the following scale:

1. I don't understand the distinction at all.
2. I have a general appreciation of the distinction but couldn't define it.
3. I can define the distinction precisely.

Hardware ↔ Software	1	2	3
Images ↔ Graphics	1	2	3
Forward chaining ↔ Backward chaining	1	2	3
Free text ↔ Coded data	1	2	3
Field ↔ Record	1	2	3
Relational database ↔ Flat-file database	1	2	3
Data in memory ↔ Data on disk	1	2	3
Sensitivity ↔ Positive predictive value	1	2	3
ICD9-CM ↔ SNOMED	1	2	3
Entities ↔ Relationships	1	2	3
Floppy disk ↔ Hard disk	1	2	3
Full-text database ↔ Bibliographic database	1	2	3
Interpreter ↔ Compiler	1	2	3
Mainframe computer ↔ Personal computer	1	2	3
Electronic mail ↔ Electronic bulletin board	1	2	3
Client ↔ Server	1	2	3
Digital ↔ Analog	1	2	3
Database ↔ Knowledge base	1	2	3

IV. Applications of Computers in Medicine

A. Priorities for future development. Listed below are 18 potential functions of computers in medicine. First, circle six functions that you consider to be of highest priority for future development. Then, circle six functions you consider to be of lowest priority for future development.

	Priority for future development	
	Highest (Choose 6)	Lowest (Choose 6)
Creating electronic medical record systems to replace the paper record	Highest	Lowest
Taking a medical history from a patient	Highest	Lowest
Entering physician orders such as laboratory tests or prescriptions	Highest	Lowest
Controlling of machine tools that assist in surgical procedures	Highest	Lowest
Performing automated interpretations of diagnostic tests (e.g., X-rays, EKGs, and pulmonary function tests)	Highest	Lowest
Assisting in the development of treatment plans for patients with complex problems	Highest	Lowest
Providing reminders to patients and clinicians of overdue visits, tests, or preventive care	Highest	Lowest
Collecting directly from patients information that is useful for screening or triage	Highest	Lowest
Augmenting medical care in geographic areas where trained personnel are not readily available	Highest	Lowest
Monitoring and adjusting life support systems in intensive-care units	Highest	Lowest
Offering advice in the diagnosis of the patient with an unknown illness	Highest	Lowest
Substituting for cadavers in the teaching of anatomy	Highest	Lowest
Teaching clinical skills to students in the health professions through clinical simulations	Highest	Lowest
Administering a medical licensure examination using simulations	Highest	Lowest
Identifying patients eligible for clinical trials	Highest	Lowest
Assisting in collecting and reporting clinical trials data	Highest	Lowest
Auditing the quality of care provided by hospitals and physicians	Highest	Lowest
Reviewing the utilization of medical resources	Highest	Lowest

B. Capabilities of future computer systems. If you were considering the use of a computer-based system in medical care, how necessary would the following capabilities be? Circle your response using the scale below.

1. **Vitally necessary:** Any system I would use must have this capability. I would not use a system that lacked it.
2. **Generally necessary:** I would be much more likely to use a system having this capability, but I might use a system that lacked it.
3. **Somewhat necessary:** I would be somewhat more likely to use a system because it had this capability.
4. **Not necessary:** My decision to use a system would be unaffected by the presence of this capability.
5. **Unable to respond:** The meaning or implications of this capability are not clear to me.

	Vitally Necessary	Generally Necessary	Somewhat Necessary	Not Necessary	Unable to Respond
I can enter information in my own words and not need to know any special codes	1	2	3	4	5
I can learn to use the system in less than two hours.	1	2	3	4	5
I can access the system at any place in the clinical setting	1	2	3	4	5
The system always responds to my queries in less than five seconds	1	2	3	4	5
The system always displays X-rays and other images in less than 30 seconds	1	2	3	4	5
I can interact with the computer without using a keyboard	1	2	3	4	5
The system can be implemented with no changes whatsoever to existing clinic routines	1	2	3	4	5

	Vitally Necessary	Generally Necessary	Somewhat Necessary	Not Necessary	Unable to Respond
The system is always functioning. There is never any "down time."	1	2	3	4	5
When a system provides medical advice on the care of specific patients, it always provides multiple alternative recommendations	1	2	3	4	5
When a system provides medical advice on the care of specific patients, it can quantify the level of certainty inherent in its recommendations	1	2	3	4	5
The system takes a patient's own preferences into account when giving advice to clinicians	1	2	3	4	5
The system can clearly explain the rationale for advice it gives on the care of patients	1	2	3	4	5
Users can browse the information in a system as well as asking it to provide advice about care of specific patients	1	2	3	4	5
The system has been demonstrated in research studies to make *diagnoses* at least as accurate as human consultants	1	2	3	4	5
The system has been demonstrated in research studies to provide *treatment recommendations* at least as accurate as human consultants	1	2	3	4	5
Help on how to use the program is available on-line	1	2	3	4	5
Level of confidentiality and security must be better than the paper record	1	2	3	4	5

C. Potential effects of computers. Given below are some effects that computers may have on medicine and health care. For each, indicate whether you believe the effect will be beneficial or detrimental using the scale below:

Effect of computers on:	Highly detrimental	Detrimental on the whole	Neither detrimental nor beneficial	Beneficial on the whole	Highly beneficial
Costs of health care	1	2	3	4	5
Clinician autonomy	1	2	3	4	5
Quality of health care	1	2	3	4	5
Interactions within the health care team	1	2	3	4	5
Role of the government in health care	1	2	3	4	5
Access to health care in remote or rural areas	1	2	3	4	5
Management of medical/ethical dilemmas	1	2	3	4	5
Enjoyment of the practice of medicine	1	2	3	4	5
Status of medicine as a profession	1	2	3	4	5
Continuing medical education	1	2	3	4	5
The self-image of clinicians	1	2	3	4	5
Humaneness of the practice of medicine	1	2	3	4	5
The rapport between clinicians and patients	1	2	3	4	5
Personal and professional privacy	1	2	3	4	5
Clinicians' access to up-to-date-knowledge	1	2	3	4	5
Patients' satisfaction with the quality of care they receive	1	2	3	4	5
Generalists' ability to manage more complex problems	1	2	3	4	5

Research Paper ■

Health Information Technology and Physician-Patient Interactions: Impact of Computers on Communication during Outpatient Primary Care Visits

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Abstract **Objective:** The aim of this study was to evaluate the impact of introducing health information technology (HIT) on physician-patient interactions during outpatient visits.

Design: This was a longitudinal pre-post study: two months before and one and seven months after introduction of examination room computers. Patient questionnaires (n = 313) after primary care visits with physicians (n = 8) within an integrated delivery system. There were three patient satisfaction domains: (1) satisfaction with visit components, (2) comprehension of the visit, and (3) perceptions of the physician's use of the computer.

Results: Patients reported that physicians used computers in 82.3% of visits. Compared with baseline, overall patient satisfaction with visits increased seven months after the introduction of computers (odds ratio [OR] = 1.50; 95% confidence interval [CI]: 1.01–2.22), as did satisfaction with physicians' familiarity with patients (OR = 1.60, 95% CI: 1.01–2.52), communication about medical issues (OR = 1.61; 95% CI: 1.05–2.47), and comprehension of decisions made during the visit (OR = 1.63; 95% CI: 1.06–2.50). In contrast, there were no significant changes in patient satisfaction with comprehension of self-care responsibilities, communication about psychosocial issues, or available visit time. Seven months post-introduction, patients were more likely to report that the computer helped the visit run in a more timely manner (OR = 1.76; 95% CI: 1.28–2.42) compared with the first month after introduction. There were no other significant changes in patient perceptions of the computer use over time.

Conclusion: The examination room computers appeared to have positive effects on physician-patient interactions related to medical communication without significant negative effects on other areas such as time available for patient concerns. Further study is needed to better understand HIT use during outpatient visits.

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Innovations in health information technology (HIT) have great potential for improving the practice of medicine; their use is encouraged by groups including national governments, the Institute of Medicine (IOM), and purchaser coalitions.[1–6] In particular, computers at the point of care, e.g., in the examination room, provide physicians with real-time access to resources such as an electronic health record, clinical decision support tools, and order entry systems during the medical visit. As examination room computing becomes more popular, it is important to understand the effects of HIT on communication and the patient-physician relationship.

Some studies suggest that HIT can improve the quality and efficiency of care delivery through better decision support.[7] Documented benefits include greater adherence to preventive care guidelines, reductions in inpatient medication errors, and reductions in the cost of care.[8–10] Other studies have found that new technology can have unintended consequences, such as increased medication order errors or increased physician time investments.[11–16] There is limited information on how computer use affects interactions between physicians and patients.[17] Previous studies have had limited ability to differentiate between changes in physician-patient communication related to physicians initially learning how to use the computer system and changes related to physicians integrating computer use into their clinical workflow.

In theory, greater and faster information availability could allow physicians more time to thoroughly explain diagnoses

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and treatments or address patient concerns. Greater access to information about previous care, medication prescriptions, laboratory test results, or clinical guidelines also could support more productive discussions about medical issues. At the same time, there might be unintended consequences of examination room computing, such as shifting the physician's attention away from face-to-face engagement with the patient and toward the computer screen and lack of focus on patients' psychosocial concerns.[18–20] Time spent navigating the computer system, searching for information, and documenting visit activities also could leave less time for patient needs, especially given the limited time available for ambulatory visits.[21–23] As with most change processes, potential adverse effects might be particularly prominent in the period shortly after implementation.

We conducted a longitudinal quantitative study to investigate how the use of computers in ambulatory primary care visits affected physician-patient interactions. Using the longitudinal experience of eight primary care physicians (PCPs), we evaluated patient satisfaction with regularly scheduled visits at three points in time: two months before and one and seven months after the introduction of examination room computers. We addressed three questions: (1) How did examination room computing affect patient satisfaction with various components of the visit, such as time spent on patient concerns? (2) How did examination room computing affect patient comprehension of the visit, such as understanding diagnoses or postvisit needs? (3) How did patient perceptions of the computer use change over time? We hypothesized that patient satisfaction with communication about medical information would increase after the introduction of the computer and that the increased emphasis on medical issues would decrease time available for patient concerns. We also hypothesized that patients would have greater comprehension of the visit and their postvisit needs after the introduction of the computer. Finally, we hypothesized that patient perceptions of computer use would improve significantly during the initial seven months after the computer introduction.

Methods

Setting

We conducted the study in one freestanding medical office building of Kaiser Permanente-Northwest, a prepaid, integrated delivery system (IDS) in the greater Portland, OR, metropolitan area.

Examination Room Computing

Although examination room computing was new to the study site, PCPs in the four clinics had had access to a commercially available electronic health record and order entry system since 1994. The HIT, developed by Epic Systems, was located in their personal offices but not in the examination room. Before the study, PCPs received basic training in how to use the system, and regularly had to use the computers to enter their progress notes as well as order medications or laboratory tests. All the physicians regularly used the computer system to document visits and enter orders but did not have the computers available in the examination room before the study; this study site was deliberately selected to permit evaluation of the introduction of examination room computers on physician-patient interactions separate from effects associated with learning how to use the system. In August 2001, the IDS introduced the computer-based system into all the examination rooms of the four clinics. The system hardware consisted of a flat panel computer screen on an adjustable, multidirectional arm, a keyboard and mouse, and a wall-mounted central processing unit (CPU). The spatial relationship between the computer CPU and monitor, the examination table, and the physician's chair varied in each examination room, depending in large part on the room's preexisting architecture. All physicians in the practice used the same examination rooms when seeing their patients; there were no systematic changes in examination room assignments after examination room computers were introduced.

Between the second and third observation periods, PCPs received training in how to integrate computers into the visit. The two-hour on-site workshop involved a didactic lecture on using the computer in an outpatient visit, group assessment of a videotape of an artificial visit, and a role-playing session. The workshop covered communication topics such as making a connection with the patient, making decisions collaboratively, establishing closure for the visit, and expressing empathy for the patient. All physicians in the study completed the training. In addition to the workshop, on-site technical support was available during all clinic hours from two part-time HIT staff persons (equal to one 100% full-time employee).

Population and Study Design

Working with leadership of the clinic and the HIT implementation team, we designed a three-period longitudinal study beginning with a baseline period (two months) before the introduction of examination room computers (P1) and two subsequent points: one month after (P2) and seven months after (P3) their introduction. We recruited PCP volunteers from the four clinics in the IDS. Eligible PCPs included physicians trained in internal medicine and family practice who provided primary care to a regular panel of adult IDS members. Eligible patient subjects included all regularly scheduled IDS members for the PCP. We obtained written consent from all patients, accompanying family members, staff, and physicians involved in the study. The Kaiser Foundation Research Institute Institutional Review Board approved the study.

During the study period between June 2001 and April 2002, there were 17 PCPs trained in internal medicine and family practice who provided care in four clinics at the study site. Of these 17 PCPs, eight agreed to participate in the study. Among patients, the overall participation rate among eligible subjects was 80%.

Data Collection

During one to two days per physician per observation period, research assistants approached all patients in each physician's waiting room. We excluded patients receiving a gynecological examination during the visit. For each consenting patient, we administered pre- and postvisit patient questionnaires, videotaped physician-patient interactions, and videotaped the computer screen. For the videotapes, we mounted one digital video camcorder from the examination room ceiling corner; we used a second camcorder to capture the video feed between the computer and the computer monitor. In this article, we report only on findings from the questionnaires.

In our effort to minimize any intrusions on the medical visit, research assistants performed all the equipment setup, tape changes, and clean up. Physicians, staff, and patients were not responsible for any part of the data collection. The cameras were minimally intrusive; a small red light indicated that the camera was recording. Noise from the cameras was negligible. Physicians, staff, and patients could either cover the camera lens using a special lens net or turn off the camera using a remote control at any point during the encounter.

Questionnaires

We pretested the written self-administered questionnaire to assess its general clarity and comprehensibility. After consenting to the study and before seeing the physician, subjects completed a one-page previsit questionnaire. Immediately after their visit, subjects completed a postvisit questionnaire, which assessed satisfaction with the visit, comprehension of diagnosis and treatment plan, satisfaction with examination room computer use, and sociodemographic characteristics. Subjects who were unable to fill out the questionnaire on site had the option of returning it by mail or completing it via telephone interview. Questionnaires were deliberately anonymous to encourage patient participation and candor.

Outcome Variables: Visit Satisfaction

Using items based in part on the Medical Outcomes Study,[24] the survey questions addressed patient satisfaction with three visit-related domains: (1) visit components, e.g., overall visit satisfaction, PCP's familiarity with the patient, communication about medical issues, communication about psychosocial issues, and time spent on patient concerns; (2) comprehension of the visit, e.g., understanding visit activities, such as diagnosis or treatment plans and determinations, and postvisit self-care needs, such as potential side effects or complications; and (3) examination room computing, e.g., impact of computer use on comprehension and personalization of care, visit efficiency and flow, and overall satisfaction with computer use (Table 1 for additional details on the wording of each item).[24,25] Rather than create summary scores for each group of satisfaction measures (e.g., satisfaction with visit components or satisfaction with psychosocial communication), we present all scores individually to allow readers to interpret each item (Table 1). Responses were based on a six-point Likert scale, which ranged from 1 (excellent) to 6 (very poor), with an additional option of N/A (not applicable).

Statistical Analyses

The unit of analysis was the patient visit. We first compared characteristics of subjects in P2 and P3 with P1; then we evaluated all the satisfaction item responses in P2 and P3 with P1 using multivariate regression models. We examined the effects of examination room computing on satisfaction levels using three different coding schemes for the outcome variables: (1) dichotomous, wherein responses of ''excellent'' were compared with all other responses; (2) a six-level categorical variable, which ranged from 1 (excellent) to 6 (very poor), and (3) a three-level categorical variable, which included 1 (excellent), 2 (very good), and 3 (good, fair, poor, and very poor). We collapsed the last category due to the few responses in the lowest four levels. We excluded N/A responses and missing values; however, we repeated analyses coding both or either value as either high or low satisfaction. Overall, the findings were robust across all approaches. In this article (Tables 1 and 2), we present the unadjusted percentage of ''excellent'' responses, i.e., the number of subjects who had excellent satisfaction on each item, and the model results that treated the outcomes as a three-level ordered categorical variable.

In the multivariate logistic and ordinal logistic regression models, we included all the patient demographic characteristics, i.e., age, gender, self-reported health status, race/ethnicity, annual household income, education, and whether the patient had previously seen the PCP. We also examined the contribution of physician characteristics to patient satisfaction in bivariate analyses but excluded them from the multivariate models. Instead, we adjusted for potential clustering of patient responses by PCP through a generalized estimating equation (GEE) approach (PROC GENMOD procedure with REPEATED option in SAS 8.2). We present the data without any specific adjustments for multiple comparisons to allow readers to make their own inferences about the appropriate confidence intervals (CIs).[26] In the text, we also focus on the comparison between P3 (seven months after introduction) and P1 (baseline), although the tables show both P2 vs. P1 and P3 vs. P1 comparisons.

Results

Eight PCPs and 313 patients participated in the study: 107 patients in the precomputer baseline period (P1), 81 in the first month after the computer introduction (P2), and 125 in the seventh month after the computer introduction (P3). Table 3 displays the characteristics of the patient subjects. The mean age was 55.2 years old (standard deviation [SD] = 16.5); 63.9% were female; 28.5% reported being in excellent or very good health; 75.4% reported being of white race/ethnicity; 31.6% reported having at least a college degree; 27.2% reported an annual household income of less than $35,000; and 79.9% reported having a previous visit with the PCP before the study visit. There were no statistically significant differences in patient characteristics across the three time periods. Table 4 displays the characteristics of the PCPs participating in all three study periods. The PCPs were evenly divided between the Departments of Family Practice and Internal Medicine; 62.5% were male; 62.5% reported being of white race/ethnicity, and 50% had 3+ years' experience within the health system.

Patients reported that their physician used the computer in the examination room in 82.3% of visits: 84.1% and 81.3% of visits in P2 and P3, respectively. As expected, patient satisfaction with the physician's use of the latest medical technology increased after the computer introduction with 35.4%, 55.7%, and 59.1% reporting ''excellent'' satisfaction in P1, P2, and P3, respectively (odds ratio [OR] = 1.71, 95% CI: 1.05–2.79 for P2 vs. P1; OR = 2.03; 95% CI: 1.47–2.80 for P3 vs. P1).

Postvisit Satisfaction with Visit Components

Overall Satisfaction

In general, patients reported high levels of satisfaction with the visit. Table 1 displays the percentage reporting ''excellent'' satisfaction with various visit-related items, i.e., a score of one out of six possible choices. There was a significant increase in the level of overall patient satisfaction with the PCP during the visit after the introduction of the computer into the examination room in the seventh month after introduction as compared with baseline, i.e., P3 vs. P1 (OR = 1.50, 95% CI: 1.01–2.22), adjusting for patient age, gender, self-reported health status, whether the visit was an initial visit, household income, and educational attainment, while allowing for clustering by physician. In addition, there was no significant drop

Table 1 ■ Patient Satisfaction with the Visit

Satisfaction with Visit Components	Unadjusted % Reporting Excellent Satisfaction			P2 vs. P1		P3 vs. P1	
	P1	P2	P3	OR	95% CI	OR	95% CI
Overall satisfaction							
Your overall satisfaction with the PCP during the visit	55.3	66.7	62.8	1.64	0.83–3.24	1.50	1.01–2.22
Familiarity							
How familiar the PCP was with you as a person	47.7	63.5	58.6	1.96	1.16–3.32	1.60	1.01–2.52
How familiar the PCP was with your medical history	42.2	46.3	49.6	1.15	0.69–1.92	1.42	1.03–1.96
Medical communication							
Explanation of your diagnoses and treatments	47.1	61.2	61.3	1.67	0.85–3.27	1.61	1.05–2.47
How much you participated in your medical care decisions	35.4	31.8	41.7	1.14	0.72–1.80	1.94	1.12–3.38
Focus on preventing illness and promoting good health	47.6	61.5	59.6	1.68	0.91–3.11	1.61	1.07–2.43
Psychosocial communication							
The personal manner of the PCP	68.2	79.1	71.7	1.67	0.95–2.94	1.21	0.70–2.09
Concern for your emotional and physical well-being	59.0	62.7	60.0	1.05	0.57–1.97	0.99	0.55–1.79
How carefully the PCP listened to you	63.6	65.7	64.6	0.95	0.52–1.75	1.02	0.61–1.70
Available time							
Time spent discussing your main reason for the visit	52.9	62.7	57.9	1.36	0.74–2.50	1.18	0.70–1.99
Time spent discussing any emotional concerns	42.5	41.7	50.0	0.85	0.52–1.36	1.23	0.74–2.05
Time available to address all your concerns	47.7	47.8	54.5	1.01	0.68–1.50	1.17	0.70–1.95
Satisfaction with visit comprehension							
Comprehension: visit activities							
Understanding your diagnosis or treatment plan	46.4	62.1	57.3	1.96	1.20–3.20	1.63	1.06–2.50
Understanding how diagnosis/treatment was determined	41.0	60.6	52.3	2.15	1.39–3.34	1.65	1.09–2.50
Comprehension: Self-care information							
Understanding self-care needed to improve health	41.3	51.6	49.5	1.60	0.98–2.60	1.29	0.73–2.27
Understanding the potential side-effects or complications	50.8	46.6	43.8	0.92	0.53–1.62	0.89	0.53–1.50

This table displays the unadjusted percentage of patients in each period who reported having excellent satisfaction with aspects of their visit and with the visit overall. The table also displays the odds of having a higher percentage of patients with excellent postvisit satisfaction during each of the postimplementation periods (P2 or P3) compared with the baseline period (P1). We calculated the odds ratios using ordinal logistic regression, which adjusted for age, gender, self-reported health status, previous visits, household income, and educational attainment and allowed for clustering by physician.
OR = odds ratio; CI = confidence interval; PCP = primary care physician.

in overall satisfaction immediately after the computer introduction (P2 vs. P1).

Familiarity and Medical Communication

Compared with the baseline period, patients in P3 also were more likely to report that physicians were familiar with them as persons (OR = 1.60, 95% CI: 1.01–2.52) and familiar with their medical history (OR = 1.42, 95% CI: 1.03–1.96). Similarly, patients were more likely to be satisfied with the level of communication about their medical care, including the explanation of diagnoses and treatments (OR = 1.61, 95% CI: 1.05–2.47), their participation in the decision-making process (OR = 1.94, 95% CI: 1.12–3.38), and the focus on preventing illness and promoting good health (OR = 1.61, 95% CI: 1.07–2.43).

Psychosocial Communication and Available Time

Patients' satisfaction with communication about psychosocial concerns was not significantly different after the computer introduction compared with the baseline: satisfaction with the personal manner of their PCP (P3 vs. P1, OR = 1.21, 95% CI: 0.70–2.09), with the PCP's concern for their emotional

Table 2 ■ Patient Perceptions of Computer Use during the Visit in the First and Seventh Months after Introduction

Computer Satisfaction Item	% Reporting Totally Agree		P3 vs. P2	
	P2	P3	OR	95% CI
The computer use helped me better understand what happened today	32.1	43.2	1.33	0.78–2.28
The computer helped the PCP know about all the things happening in my medical care	45.1	53.3	1.45	0.80–2.62
The computer helped the PCP make my care more personalized	42.3	47.3	1.23	0.77–1.95
The computer use helped the visit run in a more timely manner	34.6	50.0	1.76	1.28–2.42
The computer use fit well into the overall flow of the visit	51.9	54.9	1.19	0.72–1.95
Overall, I liked the way that the PCP used the computer in today's visit	50.0	55.6	1.26	0.85–1.87

This table displays the unadjusted percentage of patients in each period who totally agreed with statements about the quality of computer use during the visit. The table also displays the odds of having a higher percentage of patients reporting "totally agree" in the late postimplementation period (P3) compared with the early postimplementation period (P2). We calculated the odds ratios using ordinal logistic regression, which adjusted for age, gender, self-reported health status, previous visits, household income, and educational attainment and allowed for clustering by physician.
OR = odds ratio; CI = confidence interval; PCP = primary care physician.

and physical well-being (P3 vs. P1, OR = 0.99, 95% CI: 0.55–1.79) or with how carefully the PCP listened to them (P3 vs. P1, OR = 1.02, 95% CI: 0.61–1.70).

There also were no significant differences in satisfaction with the amount of time available during the visit across the three study periods. For example, there were no statistically significant differences in satisfaction with time spent discussing the main reason for the visit (P3 vs. P1, OR = 1.18, 95% CI: 0.70–1.99), emotional concerns (P3 vs. P1, OR = 1.23, 95% CI: 0.74–2.05), or the total time available to address all concerns (P3 vs. P1, OR = 1.17, 95% CI: 0.70–1.95).

Patient Comprehension of the Visit

Table 1 displays patients' satisfaction levels with their comprehension of the visit. Consistent with satisfaction regarding medical communication, patients at seven months reported having greater comprehension about their medical care during the visit, including understanding of their diagnosis or treatment plan (OR = 1.63, 95% CI: 1.06–2.50), and understanding how their diagnosis or treatment was determined during the visit (OR = 1.65, 95% CI: 1.09–2.50).

There were no significant differences in patient comprehension of medical advice at seven months after computer introduction compared with the baseline. For example, there were no statistically significant changes in understanding self-care activities needed to improve health (P3 vs. P1, OR = 1.29, 95% CI: 0.73–2.27) or knowledge of the potential side effects or complications associated with their treatments or diagnoses (P3 vs. P1, OR = 0.89, 95% CI: 0.53–1.50).

Table 3 ■ Characteristics of Patient Participants

Characteristics	Total (*N* = 313)	P1 (*N* = 107)	P2 (*N* = 81)	P3 (*N* = 125)
Age category, yr				
<30	7.0%	7.5%	6.2%	7.2%
30–39	9.9%	12.2%	8.6%	8.8%
40–49	18.5%	17.8%	18.5%	19.2%
50–59	24.6%	20.6%	28.4%	25.6%
60–69	19.8%	19.6%	22.2%	18.4%
70+	20.1%	22.4%	16.1%	20.8%
Female gender	63.9%	60.8%	65.4%	65.6%
Excellent or very good health status	28.5%	29.0%	26.0%	29.6%
White race/ethnicity	75.4%	72.0%	74.1%	79.2%
Education attainment ≥college degree	31.6%	26.2%	29.6%	37.6%
Annual household income				
Missing	26.5%	26.2%	27.2%	26.4%
<$20,000	10.9%	8.4%	12.4%	12.0%
<$34,000	16.3%	14.0%	24.7%	12.8%
<$49,000	17.9%	22.4%	12.4%	17.6%
<$100,000	25.2%	27.1%	22.2%	25.6%
$100,000+	3.2%	1.9%	1.2%	5.6%
Previous visit with PCP	79.9%	82.2%	77.8%	79.2%

None of the differences across the study periods were statistically significant at a p-value of 0.05.

Patient Perceptions of Computer Use during the Visit

Patients reported positive overall impressions of examination room computer use during the visit. The majority of patients (85.4%) reported that they totally agreed (51.4%) or agreed (34.0%) that they liked the way that their PCP used the computer during the visit. In contrast, only 6.2% of patients reported that the computer use created a distraction during the visit; 3.8% and 7.7% in P2 and P3, respectively (p = 0.37 in both bivariate and multivariate analyses). Table 2 displays the changes in perceptions of computer use between P2 and P3. The only statistically significant change in patient perceptions from P2 to P3 was an increase in satisfaction with the computer's effect on timeliness of visit activities (OR = 1.76, 95% CI: 1.28–2.42).

Discussion

In this longitudinal study of the impact of examination room computing on physician-patient interactions, overall visit satisfaction, satisfaction with the physician's level of familiarity, communication about medical issues, and the degree of comprehension with decisions made during the visit all improved significantly by seven months after implementation. Surprisingly, we did not find that the enhanced medical communication "crowded out" discussions about psychosocial issues or time for patient concerns from the patient perspective, even during the period immediately after implementation. We also did not detect any significant changes in comprehension about post-visit needs or satisfaction with the physician's personal manner, level of concern for the patient, or level of listening. Finally, we detected few changes in patient

Table 4 ■ Characteristics of Physician Participants

	(*N* = 8)
Family practice department	50.0%
Internal medicine department	50.0%
Male gender	62.5%
White race/ethnicity	62.5%
Black race/ethnicity	12.5%
Asian race/ethnicity	25.0%
Tenure <3 yr in health system	50.0%
Tenure 3–14 yr in health system	25.0%
Tenure 15+ yr in health system	25.0%

perceptions of computer use between one month and seven months after implementation.

We originally hypothesized that examination room computing might make the medical decision-making process more transparent and collaborative. In fact, patients reported that their physicians were more familiar with them, communication about medical care was better, and they understood and participated more in the medical decision-making process on average. Increases in satisfaction with the physician's use of the latest technology and familiarity with patients were expected after implementation and serve as a validity check on patient perceptions.

The lack of change from baseline to P2 in satisfaction with available time during visits was surprising. We had anticipated that physicians might have difficulty integrating computer use into their workflow during the initial months, leaving less time for patient needs, i.e., the computer would distract the PCP from the patient. We also hypothesized that availability of computer-based information could place greater emphasis on the medical aspects of the visit, thereby limiting the amount of time available for psychosocial aspects of care; however, patient satisfaction levels do not indicate that either the distraction or crowd-out phenomenon occurred. It is possible that previous experience with the computer-based electronic health record system used in the clinic could account for the absence of patient dissatisfaction after implementation.

Although the findings are generally reassuring, the data suggest opportunities for improving physician-patient interactions. For example, the level of patient comprehension of postvisit needs did not change significantly despite improvement in comprehension about what happened during the visit. Patient perceptions of the quality of computer use also did not appear to change over time, suggesting that time alone might not improve the quality of use. It may be important to continue to monitor computer use well after the initial implementation. Further research is needed to better understand the learning curve associated with successfully integrating examination room computing into ambulatory visits.

Previous studies on the impact of examination room computers are mixed. A few studies have found that introducing computers into examination rooms had an adverse effect on physician-patient communication.[18,19,23] For example, using videos of ambulatory care visits, Greatbatch et al.[20] found that physicians tended to be preoccupied with computer tasks, which hindered the flow of communication with their patients. These studies may have had limited ability to differentiate between the effects of physicians learning to use computers and electronic health records in the examination room and the office and experienced computer users attempting to integrate computers into the examination room during outpatient visits. A number of studies have found that examination room computers do not diminish patient satisfaction.[21,27–31] In some cases, computer use may actually improve certain aspects of physician-patient communication, such as physicians taking a more active role in clarifying information or encouraging patient questions, a finding similar to ours in this study.[18]

Our findings might differ from other studies because we focused on sampling at three time points rather than a single cross-sectional sample. By measuring multiple time points for each physician, we were better able to control for individual physician behaviors. In addition, by including a second postimplementation period, we were able to account for changes that may have occurred due to greater physician experience in integrating the computer into the visit. Our study also gauged the quality of physician-patient interactions by querying patients directly about their satisfaction levels and separated the responses by measures expected to improve with greater information availability and measures expected to worsen because of greater visit complexity or increased emphasis on medical information. Last, many previous studies were conducted in the late 1980s or early to mid-1990s, when computer systems might have been less user-friendly or physicians and patients less computer savvy.

This study has several notable limitations. First, this was an observational study that relied on a convenience sample of physicians and patients. Because participation in the study was voluntary, there is the potential for selection bias, e.g., early adopters or individuals more predisposed to favor computers in the examination room may be more likely to participate. The observation process and especially the videotaping also could have influenced behavior or perceptions. The study, however, focused on relative changes over time; there is no reason to expect that there would be differential effects across the three time periods.

In addition, we studied a small number of PCPs who practiced in a single clinic, within a single, integrated system. We had limited power to detect small change in our outcomes; nevertheless, we found several significant findings consistent with our hypotheses. We also relied on patient perceptions and did not attempt to directly assess areas such as patient comprehension of self-care practices. Moreover, the setting, types of physicians, and previous experience of all the physicians with the electronic health record may limit the generalizability of these findings to other contexts. We also could not adjust for any secular trends in satisfaction or in ambulatory visits, given the absence of a concurrent control group. To our knowledge, however, there were no such changes during the study period at this clinic. Finally, we did not adjust the statistical analyses for multiple comparisons.[26]

In conclusion, this early study suggests that soon after the introduction of HIT into examination rooms, physicians used the computers in the majority of ambulatory care visits and that these activities appeared to have positive effects on several aspects of physician-patient interactions including overall visit satisfaction, satisfaction with the physician's level of familiarity, communication about medical decisions, and patient understanding of the medical decisions. There did not appear to be significant negative effects on other aspects of the relationship such as communication about psychosocial needs or available time for patients' concerns. Although these findings are generally positive, much additional research is needed to confirm and elaborate on these findings, and much opportunity remains for improving the quality of physician-patient communication and for improving the integration of computers into the clinical interaction.

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Dichotomy Between Physicians' and Patients' Attitudes Regarding EMR Use During Outpatient Encounters

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ABSTRACT

Detrimental effects on physician-patient rapport are an often-voiced concern regarding the impacts of implementing an EMR in busy outpatient healthcare environments. Our objectives in this study were to: 1) identify significant concerns of physicians regarding implementation of an EMR in an outpatient clinic, both prior to implementation and after 6 months of use, and 2) assess patients' satisfaction with their outpatient encounters in this clinic, including general and EMR-specific factors. For physicians, physician-patient rapport was a concern prior to EMR implementation and increased with use of the system. In contrast, patients did not indicate a sense of loss of rapport with their physicians when an EMR was used during their outpatient visits. However, physicians and patients shared a concern about the privacy of medical information contained in an EMR.

INTRODUCTION

Implementations of electronic medical record (EMR) systems in outpatient care settings are rapidly increasing. A prominent feature of many of these implementations is physician use of the system for documentation and ordering during the patient encounter. A commonly expressed barrier to the implementation of EMRs is physician resistance; one component of which is concern for negative impacts on physician-patient relationships resulting from use of an EMR while the patient is present.[1-7]

Several studies that have examined the anticipated and actual impacts of outpatient EMRs (featuring documentation, ordering, and results reporting) on patient care, have identified physicians' concerns for the physician-patient interaction as a potential barrier to successful implementation.[5-7] Results have shown that many physicians are concerned about losing eye contact with patients[5]; keeping the patient encounter personal while focusing on data entry in the exam room[6]; or interacting with the computer in front of the patient.[7] However there is some evidence that these issues fade with increased user proficiency.[8] Other researchers have reported a more positive physician response to the use of EMRs in the exam room. When the EMR became available in Kaiser Permanente Northwest outpatient exam rooms via radio frequency-enabled laptops, it was perceived as enhancing the care experience for physicians whose access had been previously limited to their offices, perhaps because it increased the time physicians were able to spend with the patient. [9,10]

Review of the literature shows that there is very little empirical data on patient reactions to an EMR. Many of the published studies are from Europe, where these systems have been in common usage for many years.[1,11-13] Studies from the United States are very few in number, although they tend to be more current than the European studies.[2-4,14,15] Cruickshank published several early studies based on the implementation of the "First Aid" system in Great Britain.[11,12] Cruickshank found that when patients had actual experience with an EMR use during the encounter, their attitudes toward the EMR were more positive.[11] However, when asked to compare their physician against their ideal physician, patients' ratings were less positive when the EMR was used.[12] There appeared to be an effect of both age and gender, with females and older individuals exhibiting less favorable attitudes toward computer use. Brownbridge, et al. studied the effect of an EMR use in a primary care setting in Sheffield, England. [1] They found that computer use during the encounter did not affect satisfaction with the physician. Furthermore, they found no differences as a function of age or gender. Rethans, et al. reported on the implementation of an EMR in a general practice setting in the Netherlands. [13] In this study, patients felt that computer use did not make their care less personal or their communication with the physician more difficult. Notably, this group felt that with the computer, the physician was able to more efficiently assess their overall care. There was also a minority of patients in this study that expressed significant concerns about privacy with use of the EMR.

In the few published reports from the United States, the paper of Chin and McClure[14] and Aydin, et al. [15] stand out as the most significant. Chin and McClure reported on the implementation of a commercially available EMR within an HMO setting. Patient reactions to the EMR were determined by asking the physicians how the patients felt about the system. Four months after implementation, 63% of the physicians felt that patient satisfaction had improved. Since this data was not obtained directly from the patients, any effect of age or gender could not be captured. Aydin, et al. reported on use of a diagnostic-support system by nurse practitioners and physician assistants in an HMO setting. There were no differences in patient satisfaction as a function of computer use. In this study, there were no clear differences in satisfaction based on gender. However, computer users, who tended to be younger, reported less overall satisfaction. Research in which both physician and patient attitudes toward computer use were assessed, first-hand, in the same EMR implementation is very limited.[9]

Our objectives in this study were to: *1)* identify significant concerns of physicians regarding implementation of an EMR in an outpatient clinic, both prior to implementation and after 6 months of use, and *2)* assess patients' satisfaction with their outpatient encounters in this clinic, including general and EMR-specific factors.

METHODS

In Spring 1998, we began a comprehensive, longitudinal, multimethod assessment of physician and patient attitudes as part of the evaluation of the pilot implementations of an outpatient EMR in 6 practices of a large academic health system, within the context of financial, quality, and other organizational evaluation metrics. This ongoing evaluation effort seeks to develop validated, re-usable instruments and methods for evaluating these effects and to use them to improve the pilot implementations, as well as the subsequent EMR rollout to all 1700+ physicians in the health system.

The EMR implemented during this study was EpicCare, produced by Epic Systems Corporation of Madison, Wisconsin. Physicians performed all of the functions related to their outpatient practice using system workstations present in the examination rooms. Typically, past history documentation, order entry for both medications and diagnostic testing, specifications of level of service and follow-up are all handled directly with the patient present. Documentation specific to the encounter varied by provider, with some providers completing their documentation in front of the patient, and others using the system to take brief notes that were completed after the patient contact. The first pilot implementation occurred in a university-based Physical Medicine and Rehabilitation (PM&R) outpatient practice. The encounters included follow-up evaluations of individuals discharged from the inpatient rehabilitation service, as well as ambulatory evaluations for musculoskeletal problems.

We utilized the following methods in the evaluation of the EMR pilot in the PM&R outpatient facilities: *1)* pre-implementation physician survey, *2)* post-implementation physician survey, *3)* post-implementation physician interviews, and *4)* post-implementation patient surveys. The assessment methods are described in the following sections. Every effort was taken to maintain subject anonymity in the surveys. Survey data were entered into a database using a double entry method to ensure accuracy. Statistical analysis was performed using the SPSS statistical package.

Pre-implementation physician survey. A validated instrument developed by Cork, et al. [16] (and rooted in the instrument used in the oft-cited Teach and Shortliffe study[17]) was used to assess PM&R physicians' general attitudes regarding applications of computers in medicine prior to the EMR implementation. Survey items focused on physicians' demand for specific computer system features (the "feature demand" attribute) and the potentially beneficial or detrimental effects of computers on medicine and healthcare in general (the "computer optimism" attribute). Survey items also obtained demographic and computer familiarity data. Additional items were developed for this study to assess physicians' attitudes regarding the potential effects of an EMR on the respondents' medical practice. These items were adapted from the general "computer optimism" items of Cork, et al. and the results of published studies on physicians' attitudes towards EMR use. Preliminary results of a study to assess the measurement properties of this "EMR optimism" attribute support a single-factor, 21 item scale that explained 32% of the total variance with reliability of .89 (based on an N=108). The survey was distributed to 17 PM&R physicians (attendings, fellows, and residents), several months prior to implementation of the EMR in PM&R facilities.

Post-implementation physician survey. The post-implementation survey repeated sections from the pre-implementation survey for comparison. Two additional sections assessed specific EMR functionality and elicited suggested system implementation improvements. The survey was distributed to 11 PM&R physicians who had been using EpicCare during the six months since its implementation.

Post-implementation physician interviews. Semi-directed interviews were conducted with all PM&R attendings approximately one year after the system was deployed. Interview questions were developed to further explore issues raised by the pre- and post-implementation survey responses and to obtain physician responses to several survey items used in other EMR evaluation studies. The interviews were transcribed and analyzed using standard qualitative analysis methods.[18]

Post-implementation patient surveys. Following approval by the Institutional Review Board, a survey instrument for patient attitudes was developed and validated. This instrument was based on existing patient satisfaction surveys and the results of published studies on patient attitudes towards EMR use during encounters. An assessment of the measurement properties of the instrument (N=154) support a two-factor solution for patient satisfaction: a General Satisfaction attribute (a 10 item scale that explained 48% of the total variance with reliability of .94) and a Physician Computer Use attribute (a 5 item scale that explained 10% of the total variance with reliability of .84). The survey also contains items to obtain demographic data including patient familiarity with computer use. Two hundred sequential patients were surveyed over a six-month period in 1999. Both new and return patients were included, but each patient was included only once. Typically, the patient completed the survey before leaving the office after the encounter, although a small percentage returned the completed survey by mail.

RESULTS

Review of EpicCare user logs at 6 months post-implementation, indicated that the PM&R attendings were the only users of the system with enough consistent exposure to the system to assess it at this point. Therefore the results for the pre- and post-implementation surveys and the post-implementation interviews are reported for the five attending physicians who completed both surveys. Respondents included two females and three males. Their average age was 36.6 years when the pre-implementation survey was conducted.

Pre-implementation physician survey. Prior to implementation of the EMR the respondents viewed themselves as neither sophisticated nor unsophisticated users of computers. They averaged 14.2 hours of computer use per week, most frequently for such tasks as writing, preparation of presentations, communication, and occasionally to search the medical literature and the Internet and access clinical data.

Using the "EMR optimism" scale, these physicians believed that the overall effect of the EMR would be beneficial to their practices, average 0.79 (S.D. = 0.23) on a scale of –2 to 2 (-2 = highly detrimental and 2 = highly beneficial). They indicated that their chief concerns about using an EMR were related to issues of physician-patient rapport, time to document and place orders, patients' satisfaction with quality of care received, overall quality of care delivered, and physician autonomy. Results are shown in Table 1.

Post-implementation physician survey. Six months after implementation, physicians averaged a marginally significant (.089) increase of 4.4 hours per week of computer use, S.D.= 4.39 hours. While they still perceived the overall effect of the EMR to be beneficial, average 0.30 (S.D. = .07), their optimism was significantly (.005) decreased, average -0.49 (S.D. = .19). Table 1 shows that physicians' chief concerns after implementation continued to be the impact of the EMR on the time required to enter orders and document encounters and on the rapport established between physician and patient during the visit. Several decreases in individual item mean responses were significant, including patient privacy, the overall quality of healthcare that patients receive, and physician's autonomy.

Table 1. Physicians' Concerns – Pre- and Post-Implementation Survey Results*

Physicians' Concerns	Pre-implementation Survey		Post-implementation Survey		Change between Pre- and Post-implementation Periods		
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Sig. (2-tailed)
The rapport established during the encounter between clinicians and patients	-.40	.548	-.80	.447	-.40	.548	.178
Time required for documentation, such as progress notes	.20	.837	-.80	1.095	-1.0	1.871	.298
Patients' satisfaction with the quality of care they receive	.20	.447	.00	.000	-.20	.447	.374
Time required to enter orders, such as for tests or medications	.40	.894	-1.0	.707	-1.40	1.52	.108
Patient privacy	.40	.894	-.20	.447	***-.60***	***.548***	***.070***
The overall quality of health care that you give your patients	.80	.447	.20	.447	***-.60***	***.548***	***.070***
Physician autonomy	.80	.837	.20	.837	***-.60***	***.548***	***.070***

*Responses ranged from negative two ("highly detrimental") to two ("highly beneficial").

Post-implementation physician interviews. During interviews, physicians elaborated on the physician-patient rapport issue. Some stated that patients seem to pause more often while their physician was typing, requiring periodic reassurances that s/he was listening before continuing to speak. One physician owed the more halting style of his patient interactions to, *"I'm not talking to the patient as much because it is hard to type, think, and talk all at the same time."* Other physicians described the effect of using an EMR in the exam room as creating a physical barrier causing the patient to be more distant. However, several physicians stated that their patients were "getting used to the new system," that some had expressed sympathy with their physician's struggles to use it, and that most appreciate that their physician has ready access to progress notes from previous visits. Physicians could not identify any instance when a patient had expressed concern about the privacy of their medical record in the EMR.

Post-implementation patient surveys. A total of 165 surveys were completed, for an 82% response rate. Patients who refused participation were not statistically different from the rest of the sample with respect to age, but there was a tendency for a greater rate of refusal by females. The average age of respondents was 46, with a median age of 45. The age ranged from 19 to 83. Thirty-seven percent of the sample indicated that they were unsophisticated in computer use, with forty-five percent reporting no computer use during a typical week. Sixty-five percent had not encountered use of a computer during medical care in previous settings.

Results of the satisfaction scores are contained in Table 2. Patients reported being very satisfied with their medical care on the General Satisfaction Scale. The Physician Computer Use Scale also indicated very little impact of the EMR on patient satisfaction. Patient age, gender, self-rated computer sophistication or computer use did not correlate with either the General Satisfaction or the Physician Computer Use Scale. Patients reported that they did not perceive an impact of the EMR on communication or eye contact with the physician. Visits were felt to be more efficient because the doctor was using a computer, but data on length of the visits were not obtained to objectively corroborate this impression. A small percentage of patients were concerned about possible breaches of privacy through use of an EMR. This sub-group's concerns over privacy accounts for the slightly lower mean score on the Physician Computer Use Scale compared to the General Satisfaction Scale.

DISCUSSION

Detrimental effects on physician-patient rapport are an often-voiced concern regarding the impacts of implementing an EMR in busy outpatient healthcare environments. For physicians surveyed in this study, physician-patient rapport was a concern prior to EMR implementation and this concern was increased at the end of six months of use. In contrast, patients did not indicate a sense of loss of rapport with their physicians when an EMR was used during their outpatient visits with physicians in this clinic. However, physicians and patients (to a lesser degree) shared a concern about the privacy of medical information contained in an EMR.

Table 2. Patients' Satisfaction Post-implementation Survey Results*

Scales	Mean	S.D.
General Satisfaction Scale 10 overall visit and patient satisfaction items	4.59	.47
Physician Computer Use Scale 5 computer-related satisfaction items	4.00	.68
Physician Computer Use Scale Component Items		
With my medical files in the computer, I feel that my privacy is more secure than it was before	3.64	1.06
I can talk easily with my doctor when (s)he uses the computer	4.23	.79
My physician is able to maintain good personal contact with me while using the computer	4.18	.86
My visits are more efficient because by doctor uses the computer	3.79	.83
I am comfortable with the idea of my doctor using a computer to track information about me	4.15	.77

*Responses ranged from one ("strongly disagree") to five ("strongly agree").

The sample of patient's attitudes toward physician use of an EMR appears to be the largest study utilizing a validated instrument published to date. Since many of the previous studies were done in Europe or are relatively old compared to the pace of technological change, these results are important in contemplating installation of an EMR in the United States at this time. The fact the patients in this study did not feel that EMR use has a negative impact on their encounter with the physician corroborates the findings of previous studies both in Europe[1,11-14] and the United States.[2-4,9,15] The lack of an effect of age or gender parallels the findings of Brownbridge, et al.,[1] Rethans, et al.,[13] and Legler and Oates.[2] The minority of patients with serious concerns regarding privacy is similar to the finding of Rethans, et al.[13] This deserves further investigation, as privacy issues are likely to be an ongoing concern as EMR systems are implemented.

The study by Aydin, et al.[15] is most comparable to the findings presented here. That recent study from the United States had a slightly larger sample size, but the providers were nurse practitioners and physician assistants. Although it is reasonable to expect the exact type of provider should not affect the findings, replication of the results with physician providers is significant. Notably, the current study did not duplicate Aydin's finding that computer users were less satisfied with care.

Triangulation of quantitative survey data with qualitative semi-directed interviews leverages the value of our initially small physician sample. We will report the results of the full pilot implementation (100+ physicians) as the survey data is obtained. Other research has suggested that a six-month period of EMR use is too short to avoid learning-curve effects, therefore we plan to survey physicians again at two years to examine longitudinal effects.

Cruickshank showed that actual experience caused patients to have more positive attitudes towards EMR use.[11] The lack of pre-implementation patient data in the current study does not allow corroboration of this finding. Future studies using the validated patient survey tool developed for this study prior to EMR implementation would be of interest to see if patient attitudes shift as a result of experience with EMR use.

CONCLUSIONS

We have shown that physicians and patients do not agree that EMR use negatively affects physician-patient rapport during outpatient clinical encounters. However they share a concern for the privacy of the electronic medical record.

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